What is claimed is:

1. An electrochemical system adapted to operate between a fuel cell mode, an electrolysis mode, and a mode alternating between said electrolysis mode and said fuel cell mode operating on a fuel gas mixture and an oxygen-containing gas mixture, said system comprising:

at least one hollow planar cell arranged to form an electrochemical stack, said stack including an electrical contact structure at each end of said stack;

an electronically conductive, substantially impervious, hollow planar separator for separating each cell from an adjacent cell within said stack and electrically connecting each cell to an adjacent cell;

a hollow planar, substantially impervious, electrolyte within each cell;

a hollow planar fuel electrode contacting said electrolyte, said electrode being on one side of the electrolyte;

a hollow planar oxygen electrode contacting said electrolyte and on the opposite side of electrolyte from said fuel electrode;

an electronically conductive fuel diffusion layer contacting said fuel electrode, said fuel diffusion layer adapted to allow fuel and oxidized fuel transport via gaseous diffusion between the edge of said layer and said fuel electrode ;

an electronically conductive oxygen diffusion layer contacting said oxygen electrode, said oxygen diffusion layer adapted to allow oxygen transport via gaseous diffusion between the edge of said layer and said oxygen electrode;

a first seal preventing said oxygen-containing gas mixture from accessing said fuel electrode and said fuel diffusion layer; and

a second seal preventing said fuel gas mixture from accessing said oxygen electrode and said oxygen diffusion layer.

2. An electrochemical system of claim 1 wherein said oxygen-containing gas mixture is substantially pure oxygen.

3. The electrochemical system of claim 1 wherein said oxygen electrode is operated on pure oxygen gas in either of said electrolysis mode or said alternating mode, said pure oxygen gas flowing within said oxygen diffusion layer due to a substantially slight pressure gradient.

4. The electrochemical system of claim 1 wherein said at least one cell has a shape selected from the group consisting of circular, square, rectangular and oval.

5. The electrochemical system of claim 1 wherein said fuel gas mixture comprises steam and hydrogen in each of said modes.

6. The electrochemical system of claim 1 wherein said at least one hollow planar cell is defined by at least one cavity.

7. The electrochemical system of claim 1 further including an additional electrical contact layer applied to at least one side of said separator to improve the electrical contact between the components of said at least one cell.

8. The electrochemical system of claim 7 wherein said additional electrical contact layer is ink comprising finely-divided electrode composition.

9. The electrochemical system of claim 1 further including at least one supplemental high temperature mass positioned adjacent to said stack and used in combination with said stack during a temperature rise for storing high temperature thermal energy released during said fuel cell mode for later release and during a

temperature fall of electrolysis mode for reducing the electrical energy input for electrolysis.

10. The electrochemical system of claim 9 wherein said at least one supplemental mass is used to store during a temperature rise a portion of thermal energy released during cooling of a spent fuel stream from operation of said fuel cell mode for later use and during a temperature fall for helping heat said fuel gas mixture of said electrolysis mode to reduce the electrical energy input for electrolysis.

11. The electrochemical system of claim 1 wherein said fuel gas mixture flows past each cell substantially in succession thereby performing progressive reaction of said fuel gas mixture and enabling higher conversion efficiency.

12. A process for an electrochemical system adapted to operate between a fuel cell mode, an electrolysis mode, and a mode alternating between said electrolysis mode and said fuel cell mode, said alternating mode also being an energy storage system mode, wherein operation in said fuel cell mode comprises sending a current of electrons to an oxygen electrode to cause said oxygen electrode to transfer the charge of said electrons to a plurality of oxygen ions, to cause said oxygen ions to pass through an electrolyte to a fuel electrode, to cause said fuel electrode to transfer said charge back to said electrons, and to cause said electrons to be transferred to an adjacent cell of said system; wherein operation in said electrolysis mode comprises sending a current of electrons to a fuel electrode to cause said fuel electrode to transfer the charge of said electrons to a plurality of oxygen ions, said oxygen ions being formed by the decomposition of steam into hydrogen, to cause said oxygen ions to pass through an electrolyte to an oxygen electrode, to cause said oxygen electrode

to transfer the charge of said oxygen ions to said electrons, and to cause said electrons to be conducted to an adjacent cell; and wherein operation in said energy storage mode comprises alternating said system between said electrolysis mode and said fuel cell mode.

13. A solid-oxide fuel cell system adapted to operate on a fuel gas mixture and an oxygen-containing gas mixture, said system comprising:

at least one hollow planar cell arranged to form a fuel cell stack, said stack including an electrical contact structure at each end of said stack;

an electronically conductive, substantially impervious, hollow planar separator for separating each cell from an adjacent cell within said stack and electrically connecting each cell to an adjacent cell;

a hollow planar, substantially impervious, electrolyte within each cell;

a hollow planar fuel electrode contacting said electrolyte on one side of said electrolyte;

a hollow planar oxygen electrode contacting said electrolyte and on the opposite side of electrolyte from said fuel electrode;

an electronically conductive fuel diffusion layer contacting said fuel electrode, said fuel diffusion layer adapted to allow fuel and oxidized fuel transport via gaseous diffusion between the edge of said layer and said fuel electrode ;

an electronically conductive oxygen diffusion layer contacting said oxygen electrode, said oxygen diffusion layer adapted to allow oxygen transport via gaseous diffusion from the edge of said layer to said oxygen electrode;

a first seal preventing said oxygen-containing gas mixture from accessing said fuel electrode and said fuel diffusion layer; and

a second seal preventing said fuel gas mixture from accessing said oxygen electrode and said oxygen diffusion layer.

14. The fuel cell system of claim 13 wherein said at least one cell has a shape selected from the group consisting of circular, square, rectangular and oval.

15. The fuel cell system of claim 13 further including an additional electrical contact layer applied to at least one side of said separator to improve the electrical contact between the components of said at least one cell.

16. The fuel cell system of claim 15 wherein said additional electrical contact layer is ink comprising finely-divided electrode composition.

17. The fuel cell system of claim 12 wherein said fuel gas mixture flows past each cell substantially in succession thereby performing progressive oxidation of said fuel gas mixture and enabling higher conversion efficiency.